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Influence of age and sex on 19 blood variables in healthy subjects

N. Bohnen[1], C. P. Degenaar[2], and J. Jolles[1]

[1] Department of Neuropsychology and Psychobiology, University of Limburg, Maastricht;
[2] Laboratory of Clinical Chemistry, University Hospital Maastricht, Maastricht, The Netherlands

Einfluß von Alter und Geschlecht auf 19 Blutvariablen bei gesunden Personen

Summary: Normal values exist for all clinical chemical tests, but it is not very clear what is normal for healthy elderly subjects. Therefore, routine blood variables were determined in 80 ambulatory, disease-free persons who had undergone rigorous health screening. The subjects were divided into the following age groups: 20 (± 3), 40 (± 3), 60 (± 3), and 80 (± 5) years, with 10 males and 10 females per age group. Blood variables were determined after an overnight fast.

It was found that even with conservative statistical measures more than half of the variables were significantly affected by age or sex. Significant age differences were found for total cholesterol, triglycerides, sodium, and ASAT. Urea, creatinine, gamma-GT, phosphate, alkaline phosphatase, and albumin were characterized by both age and sex differences. No age or sex differences were found for glucose, potassium, chloride, calcium, calcium ion, iron, magnesium, total protein, and ALAT. The findings suggest that the age or sex-related changes of a number of blood variables such as cholesterol, triglycerides, and liver enzymes are not only of statistical significance, but are also of clinical relevance.

Zusammenfassung: Für alle klinisch-chemischen Tests gibt es Normalwerte, aber für gesunde, ältere Personen ist es nicht ganz deutlich, was als normal betrachtet werden muß. Aus diesem Grunde wurden routinemäßige Blutvariablen bei 80 ambulanten, nichtkranken Personen, deren Gesundheit gründlich untersucht wurde, determiniert. Die Personen wurden unterteilt in Altersgruppen von 20 (± 3), 40 (± 3), 60 (± 3) und 80 (± 5) Jahren mit jeweils 10 Männern und 10 Frauen je Gruppe. Blutvariablen wurden nach einer Nacht Fasten festgestellt.

Es stellte sich heraus, daß sogar mit konservativen, statistischen Meßmethoden mehr als die Hälfte der Variablen durch Alter oder Geschlecht signifikant beeinflußt wurde. Signifikante Altersdifferenzen wurden gefunden bei Cholesterin, Triglyzeriden, Sodium und ASAT. Urea, Creatinin, Gamma-GT, Phosphate, alkalische Phosphatase und Albumin wurden sowohl durch Alters- als auch Sexdifferenzen gekennzeichnet. Keine Alters- oder Geschlechtsdifferenzen wurden bei Glukose, Kalium, Chloride, Kalzium, Kalzium-Ion, Eisen, Magnesium, Totalprotein und ALAT gefunden. Die Befunde deuten darauf hin, daß die in Zusammenhang mit Alter und Geschlecht in den Blutvariablen auftretenden Differenzen nicht nur von statistischer Bedeutung, sondern auch klinisch relevant sind, wie zum Beispiel Cholesterin, Triglyzeride und Leberenzyme.

Key words: blood, aging; chemistry; healthy human; gender effect on blood variables

Schlüsselwörter: Blut, Alter, Chemie, gesunde Personen, Geschlecht

Introduction

Physicians frequently rely on blood analyses for diagnosis and treatment. Interpretation of clinical chemical results depends mainly on the use of reference intervals. Good reference data are needed for well-defined "healthy" populations and, where differences exist, data are needed for specific subgroups (e.g., age and sex). The compilation of normal values for the elderly is complicated by a number of factors, including the presence of multi-system disease, the effects of diet and nutrition, the use of medication and the physiologic and anatomic changes associated with aging.

Whether "abnormal" values in an elderly person reflect a disease process, or whether they are related to physiologic consequences of aging is not always clear. Normal values for clinical chemistry tests are often based on a hospitalized population or, alternatively, they are derived from young adults. Even when ambulatory, non-institutionalized persons are studied, their "healthiness" is often not guaranteed. Thus, in order to estimate the extent to which values differ according to age and sex, it is necessary to exclude individuals in whom these values might have been altered by disease or other con-

Table 1. Conditions and drug therapy necessitating exclusion from the study.

Diseases

- Cardiovascular arrhythmias, congestive heart disease, ischemic heart disease, systemic hypertension (diastolic blood pressure > 100 mm Hg);
- Respiratory: chronic bronchitis, acute bronchitis, bronchial asthma, pneumonia, pulmonary tuberculosis;
- Urogenital: prostatism, repeated urinary tract infections, uretero-nephrolithiasis, hematuria, proteinuria;
- Metabolic: diabetes mellitus, thyroid, adrenal, gonadal and pituitary disease;
- Neurological: Parkinson's disease, para- or hemiparesis, brain injury, mental retardation, infarcts, cerebral bleeding, epilepsia;
- Malignant neoplasms;
- Other diseases: gastrointestinal (gastric and duodenal ulcers) diseases of the liver and gallbladder; hematological diseases; rheumatoid arthritis; autoimmune diseases;
- Psychiatric: depression, psychosis, mania, anorexia nervosa.

Drugs and other agents

Antihypertensive drugs, diuretic drugs, drugs used for hyperlipemia and hypercholesterolemia, antihistamines, iron preparations, vitamin B_{12} and folic acid, anticoagulants, cytotoxic drugs, antibiotics and sulfonamides, calcium, potassium, sodium, zinc, corticosteroids, androgens, antiandrogens, anabolic steroids, estrogens, thyroid hormones, antithyroid agents, antidiabetic drugs, antiepileptic drugs, anti-Parkinson's drugs, and drugs used in gout.

ditions that could be considered to have a potential influence, such as alcohol consumption and suboptimal health.

There are very few studies with healthy subjects, i.e., those including young and old people, and often only a limited number of laboratory tests have been carried out (13). Some studies have only investigated elderly subjects, and have compared the results of these studies with "standard" reference intervals (3, 14, 21). Unfortunately, the standard reference intervals used were not specified in terms of population and health characteristics. The comprehensive study of Gillibrand, Grewal, and Blatter (10) included both young and older subjects, but did not concern healthy subjects.

Because most studies have not been concerned with a direct comparison between aged and young subjects, the purpose of the present study was to measure clinical chemistry variables in healthy, ambulatory subjects recruited outside the hospital population and covering both the young and old age ranges. The subjects were selected on the basis of rigorous health-related eligibility criteria.

Subjects and Methods

Subjects

Subjects were recruited by newspaper and circular advertisements and were paid for their participation in the study. Each subject was screened for general health in a semi-structured interview (12) and by physical examination. Subjects were invited to participate in the protocol if they had no chronic serious illness and if they had not been treated for an acute medical condition in the past 3 months. Particularly, applicants were excluded if they presented with certain conditions or had taken the drugs listed in Table 1. Pregnant females were not eligible. All subjects were free from medication except for six elderly subjects in the oldest age group (five males and one female), five of whom used daily doses of metoprolol (max. 200 mg) as treatment for well-controlled hypertension, and one sometimes used a bronchodilatator inhalator (salbutamol) for asthmatic bronchitis. The strict definition of healthiness in terms of no drug therapy and no evidence of disease was very demanding, especially in males over 75 years. From 39 such elderly males, only five met the above criteria and participated in our study. For practical reasons, we admitted the six patients medicated with the above-mentioned drugs and

Table 2. Methods of analysis. Abbreviations: ISE = ion selective electrode; mono/bi/poly-chrom = mono/bi/poly-chromatic; CV = day-to-day coefficient of variation. Analyzers: Dimension (Dupont), ICA2 (Radiometer, The Netherlands), and Cobas Bio (Hoffmann La Roche).

Analyte	Method	Analyzer	Substrate	Wave Length	CV %
K (mmol/l)	S ISE, direct sensing 37°		Dimension		0.9
Na (mmol/l)	S ISE, direct sensing 37°		Dimension		0.7
Cl (mmol/l)	S ISE, direct sensing 37°		Dimension		1.1
Total Ca (mmol/l)	S Bichrom endpoint	Dimension	0-cresolphtalein, 8-quinoliol	577, 540	0.9
Ionic Ca (mmol/l)	S ISE, direct sensing 37°		ICA2		
Mg (mmol/l)	S Bichrom endpoint	Dimension	Methyl-thymol-blue, Ba-EGTA	600, 510	3.5
Fe (µmol/l)	S Monchrom endpoint	Cobas Bio	ascorbic acid, ferrozine	562	1.2
Phosphate (mmol/l)	S Bichrom endpoint	Dimension	Sodium molybdate + p-methyl-aminophenol sulphate + $NAHSO_3$	340, 383	2.0
Albumin (g/l)	S Polychrom endpoint	Dimension	BCP	540, 600, 700	1.5
Total protein (g/l)	S Bichrom endpoint	Dimension	Cupric-sulfate	540, 700	1.1
Glucose (mmol/l)	B Monochrom rate 37°	Cobas Bio	Hexokinase	340	2.5
Total cholesterol (mmol/l)	S Polychrom endpoint	Dimension	Cholesterol-esterase, cholesterol-oxidase, horse radish peroxidase	540, 450 700	2.9
Triglyceride (mmol/l)	S Bichrom rate 37°	Dimension	Lipase, GDH	340, 383	4.5
Urea (mmol/l)	S Bichrom rate 37°	Dimension	Urease GLDH	340, 383	3,6
Creatinine (µmol/)	S Bichrom rate 37°	Dimension	Picrate	510, 600	2.7
gamma-GT (U/l)	S Bichrom rate 37°	Dimension	g-Glutamyl-3-carboxy-4-nitroanilide	405, 600	3.0
ASAT (U/l)	S Bichrom rate 37°	Dimension	L-aspartate + PSP	340, 383	3.6
ALAT (U/l)	S Bichrom rate 37°	Dimension	L-alanine + PSP	340, 383	2.9
AF (U/l)	S Bichrom rate 37°	Dimension	p-nitrophenyl-phosphate	405, 510	4.6

S = Serum, B = Blood

Table. 3. Median values and minimum-maximum ranges of routine laboratory tests per different age groups and sex.

	Males age group	median	min	max		Females age group	median	min	max
K (mmol/l)	17–23	4.17	3.72	5.25		17–23	4.11	3.65	4.52
	37–43	4.29	3.66	4.49		37–43	4.31	4.13	5.07
	57–63	4.17	3.74	4.84		57–63	4.28	3.87	4.61
	76–85	4.46	3.89	4.83		76–85	4.30	3.41	4.56
Na (mmol/l)	17–23	143	141	145		17–23	141	141	146
	37–4 3	144	143	149		37–43	144	141	146
	57–63	144	143	146		57–63	144	143	147
	76–85	143	141	144		76–85	143	141	148
Cl (mmol/l)	17–23	101	97	105		17–23	102	99	106
	37–43	102	99	106		37–43	103	101	107
	57–63	104	99	106		57–63	104	100	108
	76–85	102	100	104		76–85	102	96	104
Total calcium	17–23	2.43	2.26	2.54		17–23	2.39	2.30	2.48
(mmol/l)	37–43	2.44	2.36	2.54		37–43	2.42	2.35	2.55
	57–63	2.41	2.29	2.54		57–63	2.37	2.28	2.50
	76–85	2.32	2.22	2.47		76–85	2.34	2.19	2.64
Ionic calcium	17–23	1.29	1.22	1.33		17–23	1.25	1.14	2.27
(mmol/l)	37–43	1.24	1.22	1.33		37–43	1.27	1.22	1.29
	57–63	1.26	1.20	1.32		57–63	1.25	1.19	1.27
	76–85	1.27	1.21	1.31		76–85	1.23	1.20	1.30
Mg (mmol/l)	17–23	0.79	0.70	0.88		17–23	0.82	0.70	0.99
	37–43	0.82	0.67	0.96		37–43	0.89	0.71	0.94
	57–63	0.84	0.70	0.93		57–63	0.83	0.76	0.93
	76–85	0.84	0.69	0.95		76–85	0.82	0.68	0.89
Fe (µmol/l)	17–23	17.8	13.1	22.1		17–23	22.8	17.3	27.6
	37–43	22.1	13.8	49.5		37–43	14.6	13.8	24.9
	57–63	18.6	10.9	34.3		57–63	15.3	11.5	25.7
	76–85	19.3	14.5	31.1		76–85	18.3	7.6	27.2
Phosphate	17–23	1.21	0.97	1.56		17–23	1.12	0.96	1.43
(mmol/l)	37–43	0.91	0.75	1.19		37–43	1.10	1.00	1.45
	57–63	0.97	0.81	1.21		57–63	1.11	1.04	1.32
	76–85	1.04	0.75	1.14		76–85	1.03	0.88	1.40
Albumin (g/l)	17–23	46.0	42.0	48.0		17–23	40.5	37.0	45.0
	37–43	42.0	39.0	47.0		37–43	43.5	36.0	45.0
	57–63	41.5	37.0	45.0		57–63	39.5	34.0	43.0
	76–85	38.5	37.0	42.0		76–85	38.5	37.0	48.0
Total protein (g/l)	17–23	75.0	68.0	86.0		17–23	71.0	65.0	77. 0
	37–43	75.0	69.0	80.0		37–43	71.5	66.0	79. 0
	57–63	69.5	67.0	77.0		57–63	71.5	67.0	77. 0
	76–85	76.0	70.0	79.0		76–85	73.5	68.0	79.0
Glucose (mmol/l)	17–23	4.7	3.9	4.9		17–23	4.2	3.6	5.0
	37–43	4.3	3.8	5.3		37–43	4.6	3.5	5.4
	57–63	4.7	4.0	5.9		57–63	4.8	3.5	5.4
	76–85	4.8	4.3	8.4	N = 9:	76–85	4.6	4.3	5.8
Total cholesterol	17–23	4.1	3.5	6.3		17–23	5.4	3.7	7.2
(mmol/l)	37–43	6.1	5.0	8.4		37–43	5.8	5.1	7.2
	57–63	6.4	4.9	7.1		57–63	7.0	4.7	8.2
	76–85	6.6	5.3	8.9		76–85	6.5	5.1	8.4
Triglycerides	17–23	0.78	0.41	1.53		17–23	1.32	0.45	1.92
(mmol/l)	37–43	1.00	0.67	1.69		37–43	0.96	0.65	1.75
	57–63	1.46	0.70	2.32		57–63	1.46	0.90	2.55
	76–85	1.51	0.77	4.83		76–85	1.44	0.78	2.36
Urea	17–23	4.9	4.0	7.1		17–23	3.4	2.4	5.9
(mmol/l)	37–43	5.4	3.5	7.4		37–43	4.7	3.8	7.8
	57–63	5.7	3.5	7.0		57–63	5.4	4.0	6.9
N = 5:	76–85	7.2	4.5	8.6	N = 9:	76–85	6.2	4.2	8.9
Creatinine	17–23	76.5	68.0	97.0		17–23	70.5	64.0	85.0
(µmol/l)	37–43	86.0	64.0	103.0		37–43	69.0	58.0	87.0
	57–63	83.5	72.0	94.0		57–63	70.0	49.0	90.0
	76–85	103	95	151		76–85	71.5	62.0	98.0

Continuation of Table. 3. Median values and minimum-maximum ranges of routine laboratory tests per different age groups and sex.

	Males age group	median	min	max	Females age group	median	min	max
gamma-GT	17–23	17.0	9.0	31.0	17–23	11.0	5.0	26.0
(U/l)	37–43	23.5	15.0	93.0	37–43	15.0	10.0	20.0
	57–63	22.5	13.0	36.0	57–63	19.0	7.0	40.0
	76–85	29.0	15.0	101.0	76–85	17.5	7.0	53.0
ASAT	17–23	19.5	11.0	24.0	17–23	19.5	16.0	24.0
(U/l)	37–43	23.5	20.0	62.0	37–43	17.5	8.0	22.0
	57–63	22.5	13.0	31.0	57–63	22.0	13.0	31.0
	76–85	23.5	17.0	31.0	76–85	23.5	15.0	34.0
ALAT	17–23	21.0	15.0	33.0	17–23	18.5	16.0	24.0
(U/l)	37–43	31.5	20.0	62.0	37–43	17.5	13.0	27.0
	57–63	24.0	16.0	40.0	57–63	22.0	15.0	29.0
	76–85	21.5	12.0	31.0	76–85	20.5	11.0	32.0
Alkaline	17–23	75.5	26.0	155.0	17–23	48.5	37.0	81. 0
posphatase	37–43	53.0	20.0	78.0	37–43	55.0	33.0	75. 0
(U/l)	57–63	72.5	48.0	84.0	57–63	84.0	57.0	106.0
	76–85	84.0	27.0	108.0	76–85	68.0	49.0	91.0

treated them as a separate (relatively healthy) subgroup. Subjects were divided into four age groups: 17–23, 37–43, 57–63, and 76–85 years (10 males and 10 females per age group). There were no dietary restrictions. Subjects were of acceptable weight for height; the weight to height ratio did not provide evidence of energy imbalance. The study was approved by the medical ethical council of the hospital and all subjects gave their informed consent.

Procedure

Venous blood samples were collected (after an overnight fast) between 08.00 and 09.00 hours, with the subject in a half-sitting position. Appropriate vacuum tubes were used and approximately 100 ml blood was obtained from each subject. The mean time between withdrawal and centrifugation of the blood was less than 30 min. Blood variables were measured using routine clinical chemistry methods (Table 2). A questionnaire was completed for information concerning the use of alcohol, tobacco, caffeine, weight and height.

Statistical analysis

Because many of the laboratory values deviated markedly from a Gaussian distribution, ranks over all observations were calculated and used for a two-way ANOVA with the factors age (four levels) and sex (two levels) (4). Because of the risk of statistical error inflation due to performing multiple F-tests, the Bonferroni correction (16) was applied

Table 4. Differences in blood analytes by age, sex, and the interaction of age and sex (results of the two-way ANOVA on ranks). F-values are presented with significance levels. The Bonferroni correction for error inflation has been applied for the overall two-way ANOVA F-test (significance level $p < 0.0025$). If the overall F-test was significant, additional tests for age, sex, and interaction have been performed.

Analyte	Overall F-test	Main effects		Sex-age interaction
		Age	Sex	
	F (1,72)	F (1,75)	F (1,78)	F (1,73)
Potassium	1.65 n. s.			
Sodium	3.63 ¥	7.23***	<1 n. s.	1.25 n. s.
Chloride	2.15 n. s.			
Calcium	3.05 n. s.			
Calcium ion	2.59 n. s.			
Mg	1.44 n. s.			
Iron	2.16 n. s.			
Phosphate	6.81 ¥			5.01**
Albumin	7.84 ¥			5.48**
Total protein	3.02 n. s.			
Glucose	1.91 n. s.			
Cholesterol	5.09 ¥	9.1***	1.8 n. s.	2.18 n. s.
Triglycerides	3.65 ¥	6.39***	2.07 n. s.	1.44 n. s.
Urea	6.19 ¥	11.24***	5.6*	1.33 n. s.
Creatinine	10.42 ¥	6.21***	48.58***	1.9 n. s.
gamma-GT	6.70 ¥	7.21***	20.91***	1.55 n. s.
ASAT	3.56 ¥	4.35**	3.70 n. s.	2.70 n. s.
ALAT	2.80 n. s.			
Alkaline phosphatase	3.87 ¥			2.82*

¥ < 0.0025 (Bonferroni corrected significance level for overall F-test)
*p < 0.05, **p < 0.01, *** p < 0.001

to adjust the significance levels. Therefore, a probability level for the overall two-way ANOVA F-test of less than 0.0025 (< 0.05/19) was considered significant. In addition, Duncan's multiple range test was used as a post hoc test to evaluate significant main and interactive effects (25). There were no significant differences between age groups in the number consuming alcohol [$F(1,75) < 1$,ns], the use of caffeine [$F(1,75) = 1.46$,ns], smoking habits [$F(1.75) = 1.49$,ns] and height [$F(1.730 = 1.49$,ns]. The groups had different weights $F(1,75) = 3.49$, $p < 0.05$], the second and the third age groups being the heaviest.

Results

The results of laboratory of the 19 blood factors distributed by age and sex are summarized in Table 3. Table 4 presents the results of the two-way ANOVA for the main and interactive effects of age and sex on the selected blood analytes.

As seen in Tables 3 and 4, significant and independent age differences were found for Na, ASAT, cholesterol, and triglycerides. Na increased over the first three age groups, but decreased in the oldest age group. ASAT (aspartate aminotransferase) increased with age, whereas cholesterol and triglycerides became increasingly elevated over the first three age groups, but remained constant in the oldest age group.

Three analytes were influenced by both age and sex: 1) urea levels increased over all age groups, with males having higher values than females; 2) creatinine levels were highest in the oldest age groups, again with higher levels in older males; 3) gamma-glutamyl transferase activities increased from 40 years, with lower levels in females.

Interactive effects between age and sex were found for the following analytes: anorganic phosphate, alkaline phosphatase, and albumin. Phosphate values were highest in young males, whereas the values in females were stable over the first three age groups, followed by a decline in the oldest group. Alkaline phosphatase was higher in young males than in young females. In contrast to the levels in males, the concentrations of alkaline phosphatase rose in elderly females. No significant sex or age differences were found for K, Cl, calcium, calcium ion, Fe, Mg, glucose, ALAT (alanine aminotransferase), and total protein levels.

Further subgroup analysis of the oldest age group indicated that the small dosages of antihypertensive medication (metoprolol) taken by some subjects did not affect significantly any of the blood analytes, compared with those of medication-free subjects, with the exception of higher urea levels ($F(1,18) = 10.33$, $p < 0.01$). Despite this discrepancy, the above-mentioned increase in urea with advancing age remained significant in the metoprolol-free subjects ($F(1,67) = 7.62$, $p < 0.001$).

Lastly, the effects of alcohol usage on serum enzymes was evaluated. Fifty-four subjects (22 males and 32 females) drank no alcohol or only incidentally, whereas 26 subjects (18 males and 8 females) consumed alcohol 3 to 10 times weekly. Subgroup analysis indicated that the age-related increase in alkaline phosphatase ($F(1,50) = 3.80$, $p < 0.05$)), gamma-GT ($F(1,50) = 7.29$, $p < 0.001$), and ASAT ($F(1,50) = 5.95$, $p < 0.01$) was even more pronounced in persons who drank no alcohol or only incidentally, whereas levels of ALAT remained stable with advancing age ($F(1,50) = 1.33$ ns). In contrast, no significant age effects were found for any of the enzymes in the group who used alcohol regularly.

Discussion

The normal laboratory value for a substance is that concentration which can be measured in tissue or body fluids from apparently healthy human subjects. A "healthy" human subject is not so easily defined. An abnormal value may strictly be defined as any measurement of a body constituent that falls outside the normal range when a disease has been diagnosed by other means.

Even in healthy, disease-free elderly subjects, the physiologic changes associated with aging gradually impair the regulation mechanisms of multiple organ systems, such as renal function and cardiac output (20). The rates of change however, are variable. Studies on normal disease-free biological aging must exclude as many subjects as possible with any signs indicative of disease. In the present study, strict eligibility criteria eliminated all but five elderly "disease-free" male subjects of about 80 years out of 39 apparently "healthy" subjects. It seems reasonable, therefore, to differentiate the concept of healthiness from that of "normality". When normality is defined in terms of frequency, the majority of apparently "normal" subjects of about 80 years may not be selected as "healthy". Therefore, reference intervals for elderly persons require a strict definition of the health status of "normal" subjects (11).

Studies on human aging are beset with methodological problems, such as selection bias or limited age and population characteristics. If, for example, a reference interval is based on a hospital-derived population, one can argue that these intervals reflect a broader and more skewed range than might actually be expected for disease-free, non-institutionalized subjects (21).

The present findings suggest that a fairly large number of routine blood variables may be affected by the age and the sex of the subject. The increase in blood cholesterol and triglyceride levels in older adults is well established (4, 17, 19, 21). Total cholesterol levels tend to increase up to 65 years of age and then reach a plateau. Although sex-related differences are reported (10, 17, 19), we did not observe significant differences between the sexes for the two lipids (1).

Concentrations of electrolytes, such as Na, K, and Cl are reported to be constant with age (5, 10, 29). Although, the present study indicate that Na changes significantly with age, the observed changes do not appear to be of clinical relevance. Kanabrocki et al. (15) also reported a slight increase in serum Na and K in a longitudinal study with middle-aged males.

No sex or age differences in Mg levels were found in this study, although Lowenstein and Stanton (18) reported that Mg levels increased in females older than 25 years. Consistent with earlier reports (9), we found that levels of Fe remain stable in the elderly. In contrast, other authors have reported that Fe levels steadily decline with increasing age in both sexes (31, 32).

Data published on the effect of normal aging on serum calcium and phosphate levels are contradictory. With respect to calcium, some authors suggest that there is no change with

aging (e.g., (23)), whereas others demonstrate a decline in calcium levels with aging (8, 30). Yendt et al. (30) demonstrated that the decline in total serum calcium levels in normal elderly women was attributable to decreased levels of protein-bound calcium, and a slight reduction in levels of ionic calcium. Our data do not indicate that calcium and ionic calcium levels decline with age. The decline in organic phosphate levels with age is better established (8, 30), and sex-related differences are unequivocal.

Although the total serum protein concentration did not change with age, serum albumin concentrations decline slightly in men and women with increasing age (2, 5, 10, 24).

It has been reported that the most significant change in serum enzymes in older subjects is an increase in alkaline phosphatase in older persons of both sexes (5, 10, 26). In addition, Tietz et al. (28) have demonstrated a slight increase in the levels of ASAT and ALAT with advancing age. We found that the increase in alkaline phosphatase, gamma-glutamyl transferase, and ASAT was even more clearly related to increasing age in subjects who consumed no alcohol, or did so only incidentally. No age effect was found for the levels of ALAT. In contrast, the increase in alkaline phosphatase, gamma-glutamyl transferase, and ASAT was not observed in subjects who consumed alcohol on a regular basis (see also 5, 27). It is possible that the increase associated with aging is masked by an earlier alcohol-induced increase.

Serum urea increases markedly with age together with a less pronounced increase in creatinine concentrations (10, 21); the increase in creatinine in females may not be relevant. However, James et al. (13) and Friedman et al. (7) have reported that serum creatinine levels remain constant despite a decrease in the glomerular filtration rate because there is a simultaneous decrease in muscular mass.

The altered carbohydrate metabolism of older subjects is reflected by a slight increase in fasting plasma glucose levels, with more significant increases occurring 1–3 hours after a standardized oral dose of glucose (6, 22). The present data confirm previous observations that the possible age-related increase in blood glucose levels is very modest in healthy, non-obese individuals (3, 6, 22).

Effort is currently being taken to refine laboratory reference standards and to estimate normal developmental differences more accurately. When deviations from reference intervals become smaller, small discrepancies in reference standards become increasingly important. The laboratory intervals of mildly affected, abnormal individuals will overlap the healthy reference range. The use of appropriate (for example, age-specific) reference values will reduce this overlap to a minimum, and will make it possible to correctly classify a larger proportion of subjects. The use of separate reference values for the elderly is especially desirable when it avoids a frequent occurrence of results at the upper and lower limit of normal. Nevertheless, the use of eight different reference intervals may be too complex in clinical practice and should be limited to special purposes. The use of age-related reference intervals may have special application to the concept of an abnormality index (see (10) for further discussion). The abnormality index is a multivariate index of the correlation coefficients between a number of selected blood variables, and tries to quantify the continuum between optimum health and serious illness. Particularly in this case, the application of a biochemical abnormality index should reflect characteristics of healthy aging. Another application of age-related data concerns the group of young adults. When certain blood variables increase with age and also become more variable with age, a "normal range" based on a population of heterogeneous ages will be too high and wide for young adults. Therefore, adjustment of reference intervals for young adults may be preferable in selected cases.

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Authors' address:

N. Bohnen, Department of Neuropsychology and Psychobiology, University of Limburg, P.O. Box 616, 6200 MD Maastricht, The Netherlands.

Buchbesprechungen

Hanne Meyer-Hentschel und Gundolf Meyer-Hentschel: – Produkt- und Ladengestaltung für den Seniorenmarkt; 142 S., zahlreiche Abb., gebunden 78,– DM; ISBN 3-87150-336-3; 1991, Verlagsgruppe Deutscher Fachverlag, Frankfurt/M.

Auf den zunehmenden Anteil der älteren Bevölkerung hat sich der Markt noch nicht eingestellt. Wie man in dieser Hinsicht manches verbessern kann, legen die Autoren in dem vorliegenden Buch auf z. T. sehr anschauliche Weise dar. In einem Kapitel wird – an der Fachliteratur orientiert – auf mögliche körperliche und psychische Veränderungen beim Alternsprozeß eingegangen; dabei werden eine Reihe praktischer Konsequenzen aufgezeigt, mit denen man im Alltag, beim Ein- bzw. Verkauf diesen Veränderungen sinnvoll begegnen kann. Die veränderte Sehfähigkeit (Sehschärfe, Hell-Dunkel-Anpassung, Farbensehen, Gesichtsfeldveränderungen, Räumliches Sehen) verlangt z. B. entsprechende Maßnahmen in der Ladengestaltung, aber auch in der Produktgestaltung – Maßnahmen, die auch für andere Bereiche des Alltags (z. B. Verkehrsbetriebe, Informationen der Bundesbahn, Fahrpläne, Sitzreservierungen u. dgl. mehr) sinnvoll und hilfreich wären. Das, was in diesem Buch – wissenschaftlich begründet – über die Vermeidung von Gefahrenquellen, über die seniorengerechte Lichtgestaltung, die seniorengerechte Waren- und Angebotspräsentation wie auch über „Übersichtlichkeit und Orientierungsfreundlichkeit" (u. a. Übersichtspläne, „Siesind-hier-Pläne") ausgesagt ist, könnte zweifellos auch Behörden und anderen öffentlichen Einrichtungen als Anregung dienen. Lehr (Bonn)

Wilfried Jäckel, Kurt-A. Jochheim, Axel Stemshorn, Gerhard Andre: Qualitätssicherung und Vernetzung in der Rehabilitation; 551 Seiten; DM 48,–; ISBN 3-927-402-25-7; Universitätsverlag Ulm GmbH, Ulm

Dieses sehr informative Buch berichtet über die Jahrestagung der Deutschen Vereinigung für Rehabilitation Behinderter e. V., die 1989 in Ulm abgehalten wurde. Neben 2 Plenarsitzungen fanden 7 Arbeitsgruppen statt, die Teilaspekte des Generalthemas „Zusammenwirken und wissenschaftliche Begleitung örtlicher und überörtlicher Rehabilitationsangebote" von fast 90 Experten aus verschiedenen Berufsgruppen vertiefend behandelten. Neben Fragen der Frühförderung behinderter Kinder, der schulischen Rehabilitation, der betrieblichen und überbetrieblichen Rehabilitation, der Rehabilitation bei Schäden des Stütz- und Bewegungsapparates, Problemen der Schädel-Hirn-Verletzungen, der Rehabilitation ausgewählter internistisch erkrankter Patientengruppen (vor allem Koronarerkrankungen und Krebserkrankungen) wurden übergreifende und ortsbezogene Teamaufgaben in der Rehabilitation von Patienten mit chronischer Psychose behandelt. Es versteht sich von selbst, daß innerhalb der relevanten Themengebiete auch die Rehabilitation älterer Menschen immer wieder angesprochen wurde. Ein Beitrag von Jäckel über den Handlungsauftrag zur Fortentwicklung der Rehabilitation und von Rindt zum Entwicklungsstand der Rehabilitation und zur Lage der Behinderten in der Bundesrepublik Deutschland wie vor allem von Jochheim über „Reformchancen und Reformpotentiale für die Rehabilitation heute" schließen das vielseitige, äußerst informative Buch ab. Lehr (Bonn)